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Robotics

Lectures

CO21-006-e

Robotics in rehabilitation of walking dysfunction

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Keywords: Robotics; Gait; Neurological rehabilitation

Research groups have demonstrated that robotically mediated therapy leads to improvement in arm and leg function for patients after central nervous system (CNS) injury. For 2 decades now, research has shown robotic devices may be useful to augment outcomes of patients recovering from stroke and CNS injuries, with a focus on walking and arm function.

Patients who received robot-assisted therapy had greater recovery compared to a placebo, and improvements were maintained at a three-year follow-up. Studies of efficacy of robotic therapy have demonstrated varying degrees of success.

More recently, robots have been transformed from tethered devices to untethered mobility systems that have greatly expanded ambulation options for Individuals with Spinal Cord Injury. ReWalk^{TM} has bilateral hip and knee joint motors, batteries and a computerized control system in a backpack. Users control their walking through subtle trunk motion and changes in center of gravity. The device is intended for use with crutches for stability and because of its similarity to upright bipedal walking, it may offer the potential to resolve some of the physical and mental health problems caused by loss of walking.

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CO29-001-e

Beyond evidence: Integrating rehabilitation robotics into clinical practice

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Keywords: Stroke; Robotics; Neuro-recovery; Efficacy; Efficiency; Guidelines

Rehabilitation robotics for the upper extremity has matured quite a bit since the development of the MIT-Manus [1]. This is clearly stated in the 2010 American Heart Association and Veterans Administration guidelines for stroke care endorsing the use of rehabilitation robots for the upper extremity guidelines [2,3]. That said, robotics is no panacea and for clinical effectiveness, we should follow some basic motor learning concepts to bring the average patient improvement over the MCID of 5 points in Fugl–Meyer Assessment. Here, we will be discussing our efforts to implement robot-assisted intervention as standard clinical practice and also the many results that often challenge conventional clinical beliefs.

References

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Oral communications

CO21-001-e

The mechanical properties of the glenohumeral joint en masse: In vivo robotic testing

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Keywords: Glenohumeral joint; Joint mobilization; Robotic simulation; Load-displacement curve

Joint mobilization is characterized by great inter-subject and inter-session variability. There is a definite non-linear relationship between force exerted by the therapist and displacement (tissue-response), which are quantifiable simultaneously. We employed a 6 DOF robotic manipulator to perform AP glide mobilization movement (APG) of the glenohumeral joint (GHJ). Twenty-two healthy subjects participated. The APG movements were performed with the GHJ in 60° of ER, neutral position, and 60° of IR. Several points were determined from the load-displacement curves, the beginning of toe-region and of holding phase, the end of toe-region and of holding phase, intersection of lines representing neutral-zone and linear-elastic region.

The outcome measures were displacement, force, and stiffness. The results showed that both displacement and stiffness exhibited a main effect of arm position (P ranged from .001–.044). Significant gender effect on displacement was found. Moreover, the load-displacement relation obtained from IR and ER exchanged their priority in magnitude of displacement in toe-region. Such results may not be explained totally by the convex-concave principle; roles

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of capsuloligamentous structures have to be considered when choosing the direction of GHJ mobilization.

Further reading

Hsu AT, Chiu JF, and Chang JH. Biomechanical Analysis of axial distraction mobilization of the glenohumeral joint. Manual Ther 2009;14:381–6.

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CO21-002-e

Efficacy of robotic walk training in the early recovery period in patients after total joint replacement of the lower extremities

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Keywords: Total joint replacement; Distance robotic reconstruction

Objectives.– Study was aimed to determine the effectiveness of distance robotic reconstruction (RRH) training in patients after total joint replacement (TJR) of the lower extremities.

Methods.– In total, 162 patients with knee and 48 with hip TJR were included in the first 5 postoperative days. Then, 130 patients received RRH (study group) and 80 received only physiotherapy sessions with an instructor (control group). RRH training started on the second day after surgery and continued daily for 2–3 days. Podography, podometrics and 10-m walk test were conducted at inclusion and at the end of the treatment.

Results.– At podography, the study group compared with the control had a decrease of asymmetry of locomotion, increased smooth rolling of the foot, normalization of depreciation function, physiological load increase and participation of foot support structures in the dynamics of ongoing training, decrease in pathological inner arch overload. Analysis of pressure center migration showed: preoperatively 702.89 vs 591.54 g/cm; postoperatively 1206.51 vs 978.02 g/cm, $P = 0.009$. Results of 10-m walk test were: 38.65 vs 63.12 sec preoperatively, 15.87 vs 16.45 s postoperatively, $P < 0.05$.

Conclusion.– RRH training in the early recovery period after TJR of the lower extremities is a highly effective method of walk recovery.

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CO21-003-e

SAM, an assistive robot for persons with quadriplegia: Usability study

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Keywords: Robotics; Tetraplegia; Usability; Acceptability

Objectives.– To study the usability of the JACO robotic arm mounted on an automated mobile base across a population of 17 persons with quadriplegia vs 17 control patients.

Methods.– Usability parameters were assessed during 3 scenarios segmented into 5 steps, identifying the room, moving the robot, identifying the object, grasping the object, moving the robot back and dropping the object.

Results.– The mean success rate for each of the three scenarios varied between 98% to 100% for step 1 and 2 for both groups. Results were less consistent for step 3, 4 and 5, depending on the type of scenario. The number of user errors was predominant in the control group. The panoramic camera was almost systematically used during the 5 steps. The task of grasping object was deemed simple for all subjects included. In both groups, at least 75% of the subjects judged the robot relevant at home, for a daily use in order to reduce caregiver time or reassigning that time to other tasks.

Discussion.– This study showed a good level of acceptability and enables a targeted study on user indications.

Partners.– Centre Bouffard-Vercelli (66), Centre Jacques Calvé (62), LASMEA, CNRS-LIMSI, VOXLER, ROBOSOFT.

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CO21-004-e

Retrospective analysis of upper limb motor recovery after prolonged robot-assisted training in subacute stroke

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Keywords: Hemiparesis; Upper limb; Subacute stroke; Prolonged robot-assisted training

Background.– High intensity of rehabilitation has been demonstrated to enhance motor recovery after stroke. The evolution of upper limb motor kinematics during prolonged robot-assisted training is yet to be determined.

Methods.– This retrospective study in 10 patients with subacute hemiparesis (age 48 ± 20; time since stroke 54 ± 16 days; stroke type 8 ischemic, 2 hemorrhagic; paresis side 5 L) analyzed hand kinematics recorded by the robot before onset and following 6, 12 and 18 weeks (W1, 6, 12, 18) of robot-assisted upper limb training. In addition, the Fugl–Meyer score (FM) and Motor Status Score (MMS) were assessed at W1, 6 and 12 in 8 patients.

Results.– While improvements in hand kinematics occurred only during the first third of the training period (W6; task success index, +97%, $P = 0.024$; trajectory RMS, –45%, $P = 0.044$; hand velocity, +335%, $P = 0.0028$; hand trajectory reversals, –38%, $P = 0.034$), motor impairment scores increased at W6 (FM, +48%, $P = 0.018$; MSS, +64%, $P = 0.012$) and W12 (vs W6, FM + 23%, $P = 0.012$; MSS, +30%, $P = 0.017$).

Conclusion.– This retrospective study suggests that prolonged robot-assisted training in subacute stroke is associated with continued reduction of motor impairment up to 12 weeks after treatment onset.

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Walking robotic assistance: Assessment of the hip and knee range of motion among post stroke patients

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Keywords: Gait; Stroke; Evaluation; Robotic assistance; Range of motion

Objective.– To study the ranges of motion developed during walking by post-stroke patients on an electromechanical gait trainer, the Lokohelp®.

Method.– Ten patients were equipped with electronic goniometers. Data were collected at the 2nd minute (M2), the 5th minute (M5) and the 8th minute (M8). Hip and knee extension and flexion on the paretic and the healthy sides were analyzed.

Results.– On the paretic side, insufficient joint extension was observed; only 37% of patients had a physiologic hip extension, 30% had normal knee extension, 23% had normal hip flexion. The amplitudes of the healthy side were more physiological, 57% of patients had hip extension within norms and 53% had normal knee extension. Knee recurvatum was observed only on the healthy side. Reproducibility was good except for the healthy knee.

Discussion/conclusion.– These results can be explained by insufficient body weight support, lack of active participation by the patient (especially for the paretic side), uncontrolled pelvis movements and two characteristics of this device: the ankle immobilization in the orthoses and the fixed length step. Nevertheless, these results call into question the relationship between the efficacy of this kind of assistive walking devices and the ranges of motion actually induced.

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